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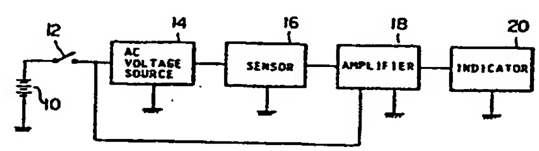
(54) Oil deterioration detector.

(57) An apparatus detects the degree of deterioration of lubricating oil used in an internal combustion engine by measuring the dielectic constant of the lubricating oil. The apparatus includes a sensor (16) having a pair of spaced apart electrodes dipped under the lubricating oil to form a sensor capacitor whose capacity varies as a function of the dielectric constant of the lubricating oil. The sensor capacitor is connected to a fixed capacitor to form a voltage divider connected across an AC voltage source (14) which generates an AC voltage of a constant frequency so that a voltage is developed across the sensor capacitor which voltage corresponds to the dielectric constant of the lubricating oil. The frequency of the AC voltage is set at a value ranging from 50 KHz to 500 KHz.

FIG.1



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DESCRIPTION

This invention relates to an apparatus for detecting the degree of deterioration of lubricating oil used in an internal combustion engine and, more particularly, to such an apparatus utilizing a pair of spaced apart electrodes dipped under the lubricating oil to form a sensor capacitor whose capacity varies as a function of the dielectric constant of the lubricating oil.

Lubricating oil gets deteriorated to have its lubricating ability reduced due to entrance of contaminants such as soot after a number of uses in an internal combustion engine. It is desirable to know the state of the lubricating oil so that the oil can be changed at a proper time.

In order to determine the degree of deterioration of lubricating oil, it has been the practice in the past to measure the conductivity of the lubricating oil by sensing current flow between a pair of electrodes dipped in the lubricating oil within an oil pan. However, the conductivity of lubricating oil varies greatly with its temperature and brand to such an extent as to completely invalidate the expected relationship between the measurement of the conductivity of the lubricating oil and the degree of deterioration of the lubricating oil. This is true particularly for diesel engines where a great

amount of soot enters lubricating oil.

Therefore, the present invention provides an apparatus which can detect the degree of deterioration of lubricating oil with greater accuracy independently of lubricating oil temperature and brand. Applicants have found the fact that variations in the capacity or impedance of a sensor capacitor comprised of a pair of spaced apart electrodes dipped under lubricating oil are in good correspondence with the extent to which the lubricating oil gets deteriorated. The present invention utilizes the variations as an indicator of oil deterioration.

There is provided, in accordance with the present invention, an apparatus for detecting the degree of deterioration of lubricating oil used in an internal combustion engine. The apparatus comprises a sensor including a pair of spaced apart electrodes dipped under the lubricating oil to form a sensor capacitor whose capacity varies as a function of the dielectric constant of the lubricating oil. An AC voltage of a constant frequency is applied to the sensor capacitor so that the sensor generates an output corresponding to the dielectric constant of the lubricating oil. The output of the sensor is applied to an oil deterioration indicator which thereby indicates the degree of deterioration of the lubricating oil corresponding to the sensed lubricating oil dielectric constant. The frequency of the AC voltage is set within a

range of 50 KHz to 500 KHz. This is effective to avoid adverse influences of oil temperature changes on the measurement of the dielectric constant of the lubricating oil.

The details as well as other features and advantages of this invention are set forth below and are shown in the accompanying drawings, in which:

Fig. 1 is a block diagram showing one embodiment of an oil deterioration detector made in accordance with the present invention;

Fig. 2 is a graph showing variations in the impedance and capacity of the sensor capacitor with the lubricating oil being getting deteriorated;

Figs. 3A, 3B and 3C show two different forms of the sensor capacitor;

Figs. 4A and 4B are schematic views showing a lubrication system in which the sensor capacitor is placed;

Fig. 5 is a schematic view showing a lubrication system oil passage in which the sensor capacitor is placed;

Fig. 6 shows an oil chamber formed in the lubrication system for reception of the sensor capacitor;

Fig. 7 is an elevational view showing a gauge included in the oil deterioration indicator of Fig. 1;

Fig. 8 is a circuit diagram showing a circuit for adjusting the gauge of Fig. 3;

Fig. 9 is a circuit diagram showing a modified

form of the oil deterioration indicator;

Fig. 10 is a comparative graph showing impedance versus AC voltage frequency curves obtained on new and used lubricating oil at low and high temperatures;

Fig. 11 is a comparative graph showing specified inductive capacity versus AC voltage frequency curves obtained on new and used lubricating oil at low and high temperatures; and

Fig. 12 is a circuit diagram showing a modified form of the oil deterioration indicator.

Referring now to Fig. 1 of the drawings, there is shown one embodiment of an oil deterioration detecting apparatus made in accordance with the present invention. A DC power source 10 is connected through a main switch 12 to an AC voltage generator 14. The AC voltage generator 14 comprises a CR oscillator or a crystal oscillator for generating an AC voltage of a constant frequency when the main switch 12 is closed. The frequency of the AC voltage is selected at a value within a range of 50 KHz to 500 KHz as will be described in detail. The AC voltage is applied to a sensor 16 which generates an AC voltage corresponding to the degree of deterioration of an engine oil used in an internal combustion engine. The output of the sensor 16 is coupled through an amplifier 18 to an oil deterioration indicator 20 for providing an indication of the sensed degree of oil deterioration.

The sensor 16 includes a sensor capacitor which has a pair of spaced apart electrodes dipped under the lubricating oil so that the sensor capacitor has a capacity more than 400 PF to avoid an adverse influence of floating capacity. For example, the electrodes may be taken in the form of about 200 cm^2 area plates spaced apart a distance of about 1 mm from each other. The impedance and capacity of the sensor capacitor vary as a function of the dielectric constant or permittivity of the lubricating oil, as shown in Fig. 2. As the lubricating oil gets more deteriorated to increase its dielectric constant, the sensor capacitor impedance decreases as illustrated by impedance versus oil deterioration curve IP and the sensor capacitor capacity increases as illustrated by capacity versus oil deterioration curve CP. The sensor also includes a circuit which connects the sensor capacitor to the AC voltage generator for generating a sensor output corresponding to the dielectric constant of the lubricating oil. The circuit may be taken in the form of a capacitor having a fixed capacity, in which case the capacitor is connected in series with the sensor capacitor to form a voltage divider which divides the output voltage of the AC voltage generator 14 at a ratio determined by the dielectric constant of the lubricating oil so that the AC voltage across the sensor capacitor is substantially proportional to the engine oil dielectric constant.

The sensor capacitor may be a variable capacitor,

as shown in Fig. 3A, which comprises one set of parallel plates 162 moving in relation to another set of parallel plates 164 to have every possible value of capacity within its range. Alternatively, the sensor capacitor may have one set of concentrically arranged cylindrical plates 166 placed in relation to another set of concentrically arranged cylindrical plates 168 as shown in Figs. 3B and 3C. Such capacitor arrangements are effective to reduce the sensor size and facilitate the lubricating oil to shift through the sensor capacitor. The sensor capacitor may be a printed electrode plate having a desired electrode figure printed on a tip plate.

Referring to Figs. 4A and 4B, there is illustrated a lubrication system which includes a pump 22 for supplying engine oil under pressure through an oil filter 24 to a main gallery 26. The sensor capacitor 160 is placed in an oil chamber 30 formed in an oil passage 28 downstream of the main gallery 26 or in an oil passage 32 downstream of the oil filter 24. The oil chamber may be formed in other suitable position as long as there is a minimum amount of contaminants and the engine oil flows at a relatively high rate in order to keep the sensor capacitor free from any deposite on its electrode surfaces. This is effective to keep at a minimum changes in the characteristics of the sensor capacitor with time. Alternatively, the oil chamber 30 may be formed in a return passage 34 leading to an oil pan with another oil filter 36

being positioned in the return passage 34 upstream of the oil chamber 30 as shown in Fig. 5.

Referring to Fig. 6, the oil chamber 30, which contains the sensor capacitor 160, has an inlet 30a formed near its bottom and an outlet 30b formed in its upper wall so that air cannot be stored in the oil chamber 30. Preferably, the sensor capacitor 160 is placed in the oil chamber 30 to provide a space of ℓ between its electrodes and the oil chamber upper wall with its electrodes extending vertically toward the oil chamber upper wall to avoid existence of air bubbles between the sensor capacitor electrodes to change the capacity of the sensor capacitor. The sensor capacitor electrodes are coated on their surfaces with a corrosion protective material such as fluorocarbon polymers to protect them against acids and bases included in the lubricating oil. This is also effective to prevent DC conduction from occurring due to entrance of contaminants between the sensor capacitor electrodes.

The output of the sensor 16 is applied to an amplifier 18 which amplifies the AC voltage across the sensor capacitor and applies the amplified AC voltage to the oil deterioration indicator 20. The amplifier 18 may have an additional function of converting the amplified AC voltage value into a corresponding DC voltage value.

Referring to Figs. 7 and 8, the oil deterioration indicator 20 includes a gauge 202 which has a pointer 204

and a scale with ranges classified by color. The gauge 202 is associated with a sensitivity adjusting circuit 210 and a zero setting circuit 220. The sensitivity adjusting circuit 210 is taken in the form of a variable resistor for adjusting the sensitivity of the gauge 202 by varying its resistance within its range. The zero setting circuit 220 comprises a potentiometer 222 connected between a DC power source 224 and electrical ground. The wiper arm of the potentiometer 222 is connected to one end of the gauge 202 for setting the gauge pointer 204 to correspond with the scale zero by moving the wiper arm within its range. The other end of the gauge 202 is connected to the output of the amplifier 18 so that the gauge pointer 204 rotates an angle corresponding to the output of the amplifier 18 to point a colored scale range which indicates the degree of deterioration of the engine oil.

Referring to Fig. 9, there is illustrated a modification of the oil deterioration indicator 20 wherein it comprises a buzzer 230 connected at its one side to a DC power source 232 and at the other side to the collector of a transistor 234 whose emitter is grounded. The base of the transistor 234 is connected through a resistor to the output of a comparator 236 which has a positive input terminal connected to the output of the amplifier 18 (Fig. 1). The negative input terminal of the comparator 236 is connected to a reference voltage source 238 which is taken in the form of a voltage divider connected across the

DC voltage source 232 for generating a reference voltage which represents a reference oil deterioration degree at which the engine oil is required to be changed. When the output of the amplifier 18 reaches the reference voltage, the comparator 236 generates a high output which conducts the transistor 234 to sound the buzzer 230. The indicator 20 may utilize a conventional oil-pressure light which gives light indication whenever the oil pressure is below a predetermined level. In this case, the oil-pressure light may come on at predetermined intervals when the oil deterioration degree reaches the reference value to make a distinction the oil deterioration degree indication from the insufficient oil pressure indication.

Fig. 10 shows comparative curves of impedance versus AC voltage frequency. The curve marked A is obtained on new engine oil at high temperature and the curve marked A' is obtained on new engine oil at low temperture. The curve marked B is obtained on used engine oil at high temperature and the curve marked B' is obtained on used engine oil at low temperature. From Fig. 10 it may be seen that a greater change is caused in the impedance of the sensor capacitor by engine temperature changes than is caused by oil deterioration when the frequency of the AC voltage applied to the sensor capacitor is below about 50 KHz. Comparative specific inductive capacity curves are given in Fig. 11. The curve marked C is obtained on new engine oil at high temperature and the curve marked C' is

obtained on new engine oil at low temperature. The curve marked D is obtained on used engine oil at high temperature and the curve marked D' is obtained on used engine oil at low temperature. It may be seen from Fig. 11 that a greater change is caused in the specific inductive capacity of the engine oil by engine temperature changes than is caused by oil deterioration when the frequency of the AC voltage applied to the sensor capacitor is below about 50 KHz.

The frequency of the AC voltage applied from the AC voltage generator 14 to the sensor 16 is set at a value within a range of 50 KHz to 500 KHz. If the frequency is lower than this range, the oil deterioration measurement made in the sensor 16 is susceptible to influences from engine temperature changes, causing an improper indication of oil deterioration degree. If it is higher than the range, radio interference occurs in AM band. Preferably, the frequency is set at 100 KHz. Experiments show that any deviation which appears on the output of the sensor 18 due to use of lubrication oil of different brands can be ignored in practice.

Referring to Fig. 12, there is illustrated an alternative form of the oil deterioration indicator 20 wherein a circuit is associated with the gauge 202 for placing the gauge 202 in operation only when the engine temperature is above a predetermined value, for example, $80^{\circ}C$. This is effective to avoid adverse influence of

engine temperature changes on the indication of the oil deterioration degree. The circuit comprises a thermistor 242 connected in an electrical circuit capable of producing a DC voltage having a variable level corresponding to the engine temperature represented by the engine coolant temperature. The output of the thermistor 242 is connected to the negative input terminal of an comparator 244 whose positive input terminal is connected to a reference voltage source 246 which is taken in the form of a voltage divider connected across a DC voltage source 248 for generating a reference voltage which represents the predetermined temperature value. The output of the comparator 244 is connected through a diode 250 and a resistor 253 to the base of a transistor 256 whose emitter is grounded through the gauge 202. The collector of the transistor 256 is connected to the positive terminal of the DC power source 248. The base of the transistor 256 is connected through a resistor 254 to ground and also to the output of the amplifier 18. When the engine coolant temperature reaches the predetermined value, the comparator 244 generates an high output which conducts the transistor 254 to place the gauge 202 in operation.

While the present invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art.

Accordingly, it is intended to embrace all alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

CLAIMS

1. An apparatus for detecting the degree of deterioration of lubricating oil used in an internal combustion engine, c h a r a c t e r i s e d by:

(a) an AC voltage source (14) for generating an AC voltage of a predetermined frequency ranging from about 50 KHz to about 500 KHz;

(b) a sensor (16) including a pair of spaced apart electrodes (162,164;166,168) dipped under the lubricating oil to form a sensor capacitor whose capacity varies as a function of the dielectric constant of the lubricating oil and a circuit connecting said sensor capacitor to said AC voltage source (14) for generating an output corresponding to the lubricating oil dielectric constant; and

(c) an indicator (20) connected to said sensor (16) for indicating an oil deterioration degree corresponding to the output of said sensor.

2. Apparatus according to claim 1, c h a r a c t e r i z e d in that said AC voltage source (14) generates an AC voltage of a constant frequency of 100 KHz.

3. Apparatus according to claim 1 or 2, c h a r a c t e r i z e d in that said indicator (20) includes a gauge (202) for providing an oil deterioration degree indication corresponding to the output of said sensor (16) and means (242,244,256) for holding said gauge (202) out of operation until the engine temperature reaches a predetermined value.

4. Apparatus according to claim 1, c h a r a c t e r i z e d in that said indicator (20) includes a buzzer (230) and means (236,234) for sounding said buzzer when the output of said sensor (16) reaches a predetermined value.

5. Apparatus according to any of the above claims, c h a r a c t e r i z e d in that said sensor capacitor is a variable capacitor including one set of parallel metal plates (162) moving in relation to another set of parallel metal plates (164) to have every possible value of capacity within its range.

6. Apparatus according to any of the claims 1 to 4, c h a r a c t e r i z e d in that said sensor capacitor includes one set of concentrically arranged cylindrical metal plates (166) arranged in relation to another set of concentrically arranged cylindrical metal plates (168).

7. Apparatus according to any of the above claims, c h a r a c t e r i z e d in that said circuit includes a capacitor of a fixed capacity, said capacitor being connected in series with said sensor capacitor to form a voltage divider connected across said AC voltage source (14) so that an AC voltage corresponding to the lubricating oil dielectric constant is developed across said sensor capacitor.

FIG.1

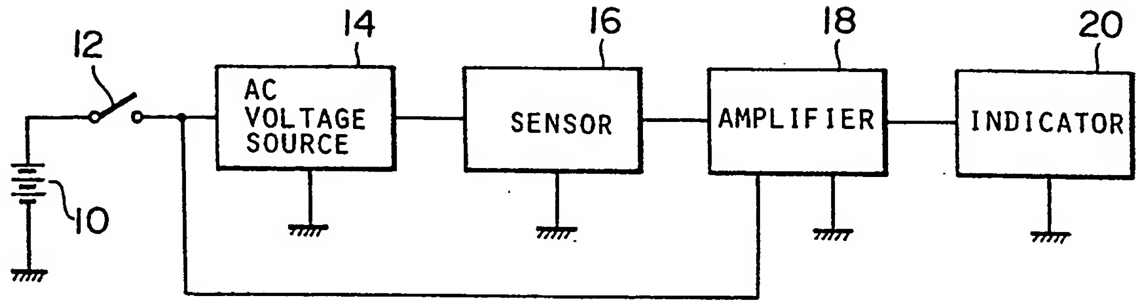

12
14
16
18
20
AC VOLTAGE SOURCE
SENSOR
AMPLIFIER
INDICATOR
10

FIG.2

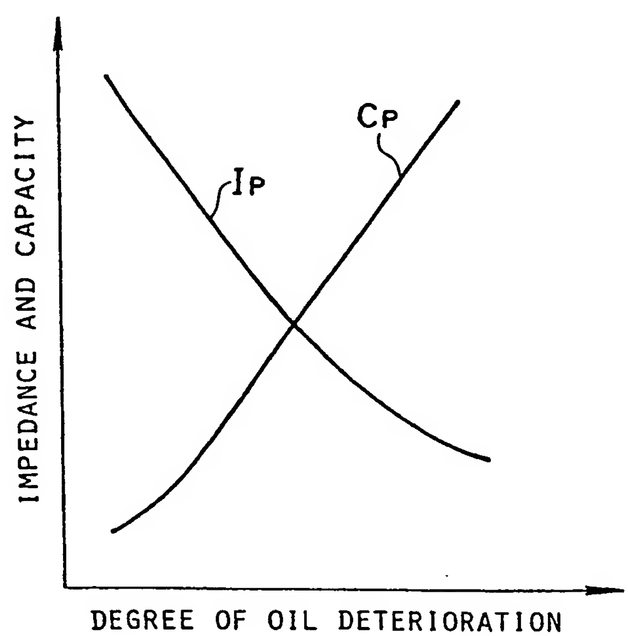

IMPEDANCE AND CAPACITY
C_P
I_P
DEGREE OF OIL DETERIORATION

FIG.3A

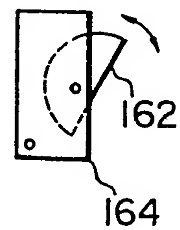


FIG.3B

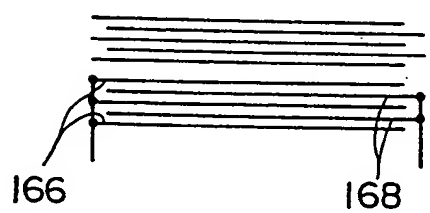


FIG.3C

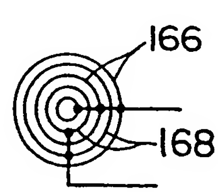


FIG.4A

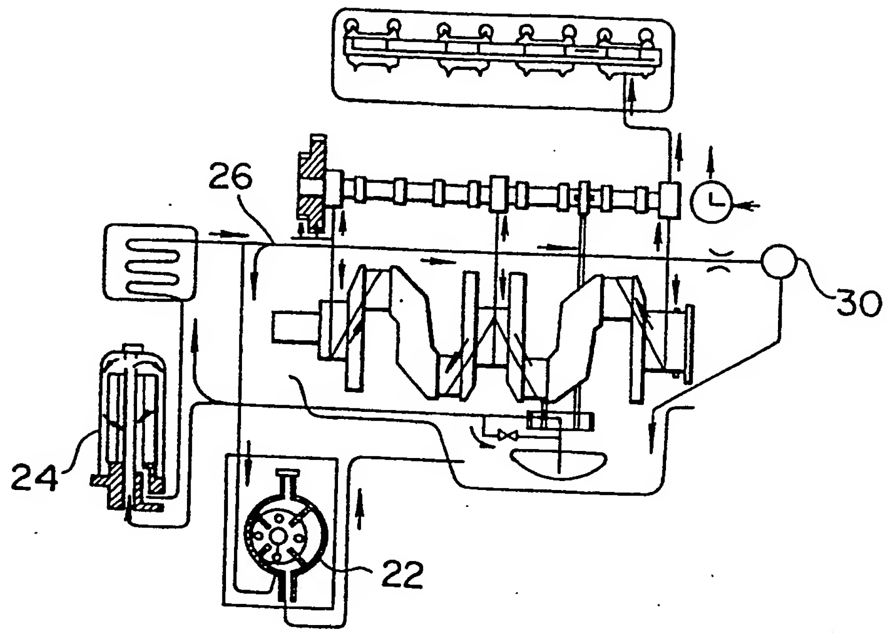


FIG.4B

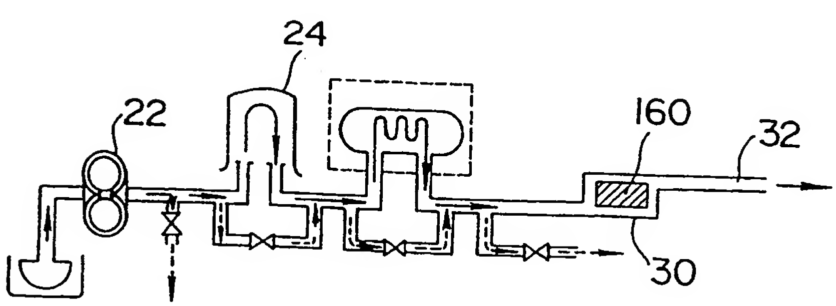


FIG.5

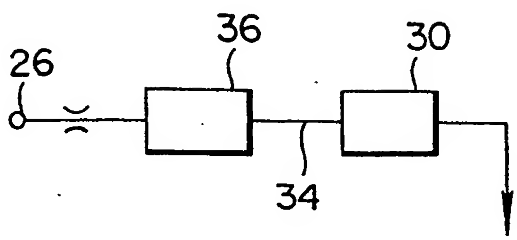


FIG.6

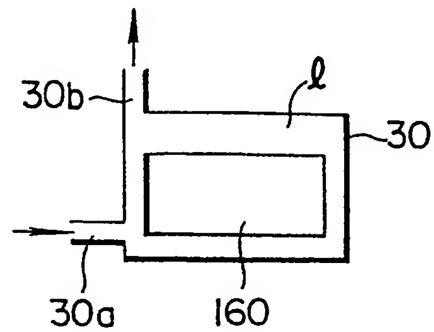


FIG.7

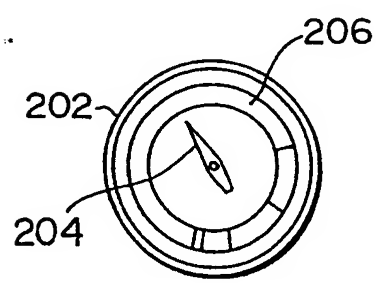


FIG.8

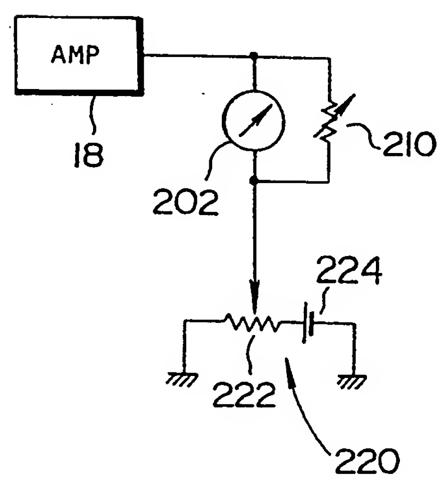


FIG.9

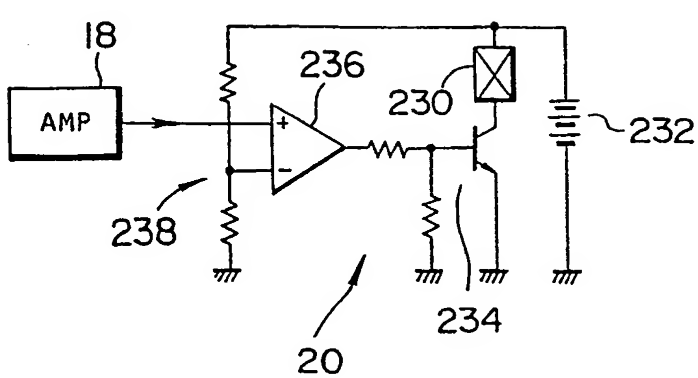


FIG.10

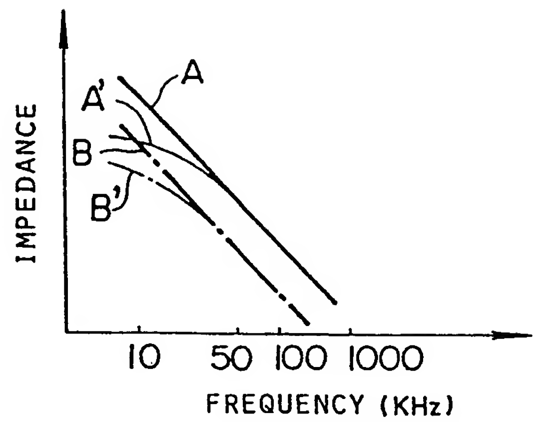


FIG.11

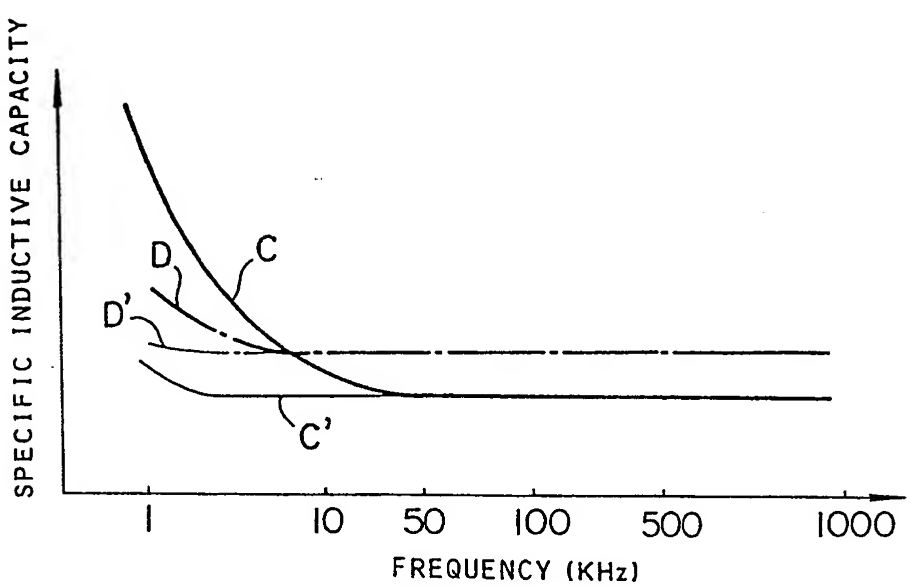
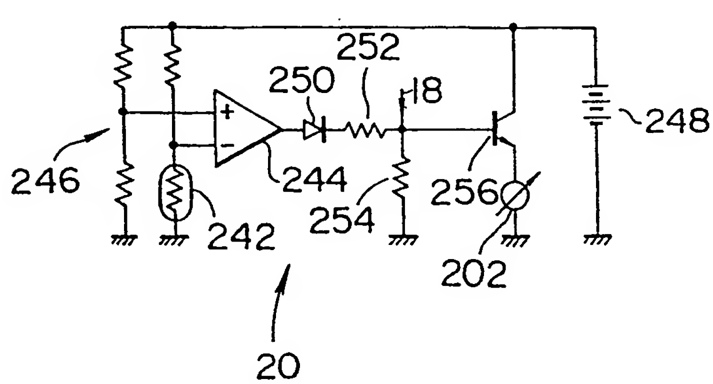


FIG.12



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EUROPEAN SEARCH REPORT

0080632

Application number

EP 82 11 0482

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Y	EP-A-0 001 919 (GEORGETOWN UNIVERSITY) * Claims 1-5, 12, 13, 15; figure 9; page 2, lines 10-24; page 6, lines 2-6; page 13, lines 2-28 *	1,2,5, 7	G 01 N 27/22 G 01 R 27/26
A		4	
Y	DE-A-2 120 744 (CHEVRON RESEARCH CO.) * Pages 1-5 *	1,2	
Y	US-A-3 067 385 (F.B. RYKOSKEY) * Claims 1-4; figure 2; column 2, lines 41-68 *	1,5,7	
			TECHNICAL FIELDS SEARCHED (Int. Cl ³)
Y	JOURNAL OF PHYSICS. E. SCIENTIFIC INTRUMENTS, vol. 12, no. 9, 1979 J. BLOM "Measurement of dielectric relaxation of conducting solutions at low frequencies" pages 889-893 * page 889 *	1	G 01 N 27/00 G 01 N 33/00 G 01 R 27/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	10-02-1983	DIETRICH A.

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